ICE THICKNESS IN THE MACKENZIE DELTA:

WINTER 1983-84

DATA OBTAINED FROM HOT-WIRE GAUGES

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INTRODUCTION

Following a successful ice gauging program in the 1982-83 winter (Sherstone, 1984) a second program was undertaken in 1983-84. The start-up was delayed, initially due to ice road conditions, and subsequently by reduced manpower at the Resource Centre. As a result, gauge installation was made, when weather permitted, between late January and early March. For the 1983-84 season, gauges were located on seven major, northward flowing channels, along an east-west transect between Inuvik and Aklavik (Figure 1). A total of 20 gauges were installed.

Modifications to the weight/wire assembly were made to speed construction of the gauges and reduce both cost and installation time.

Whenever possible, gauges were read once per week. Readings continued to mid-May, with the last readings being taken on May 16th. Helicopter support was required for the last set of readings. At that time the above-ice components of each gauge were removed.

Data obtained from similar locations for each of the winters (Bombardier Channel and Middle Channel) exhibit similar ice thickness values throughout the period of common record. The pattern of ice growth and decay during the 1983-84 winter appears similar to that of 1982-83. Ice growth continued into late April or early May. Maximum ice thickness was lowest at sites near the east side of the Delta and increased progressively towards the west side. The maximum thickness recorded was at the West Channel site, immediately downstream of Aklavik, where a value of 150 cm (at gauge 84-20) was obtained on May 3. Of this total thickness only 2.5 cm was "white" ice, which had formed between April 27 and May 3.

MODIFICATION OF GAUGES

Gauges used during the 1983-84 winter were modified, from those used in 1982-83, in the weight and wire assembly. These modifications permitted easier assembly and installation. The 'T' bar at the top of the weight assembly in the 1982-83 gauge was eliminated in order to permit easier installation through the ice (Figure 2).

The electrical junction at the weight assembly in the 1983-84 assembly also provided the mechanical connection of the weight to the resistance wire/support frame. The continuity of each wire assembly

"loop" was checked after assembly and again immediately after installation.

As in the previous winter, the design and construction of the components of the gauges was undertaken by the Instrument and Technology Services Section, National Hydrology Research Institute, Environment Canada.

INSTALLATION AND MONITORING OF GAUGES

Gauges were not installed at the optimum time in 1983-84; being positioned between January 23 and March 1. The delay in commencing was caused by manpower constraints during the November to January period. Once installation started, it was repeatedly delayed by extreme cold weather, wind and/or road conditions.

The actual installation was straight forward. At each site a transect was selected and the required number of properly-spaced gauge locations shovelled free of snow (an area approximately 1.5 x 1.5 m). A single hole was drilled through the ice to permit lowering the weight-wire assembly, and the support stand placed on the ice surface. Slush and water from the hole were used to freeze the baseplate to the surface. At the air temperatures' extant during installation, freezing usually occurs within one to two minutes. The total time required to install each gauge was approximately 15 minutes.

At three of the sites (East Channel, Bombardier Channel and Oniak Channel) temporary benchmarks were established at each end of the transect to permit monitoring vertical movements of the ice surface.

In mid-May the last readings were done by helicopter after excessive overflow caused closure of the ice roads. After a final reading the wires were cut close to the ice surface, releasing the weight assembly, and the remainder of the gauge removed. At the time of the last reading, most gauges were thawed free of the ice surface and little effort was required for removal.

One gauge (Napoiak Channel, 84-15) stopped functioning during the coldest part of the winter. Repeated attempts to heat the wire during this period failed. In early April, as air temperatures rose, the gauge again started working. No cause for this failure was determined. All other gauges functioned without problems throughout the study period.

During May readings, electrical power was not required to free the resistance wire from the ice. Solar heating of the wire was sufficient to keep the wire free at all gauges at sites with an ice thickness of less than 120 cm. The net erosion of the ice at the ice-water interface due to heat transfer down the wire was not determined.

DISCUSSION OF RESULTS

The gauge sites used in 1983-84 differed from those of 1982-83. In 1982-83 the main purpose of the program was to test the equipment and methodology of the modified hot-wire gauge in sub-Arctic freshwater ice. In 1982-83 different channel sizes and channel characteristics were selected and a lake site used. These sites represented;

a) lakes in a bedrock zone, away from the main Delta,
b) small and medium sized channels in the eastern half of the Delta,
c) a large channel,
d) a northern Delta location (in an attempt to measure the ultimate ice measurement ability of the gauge).

For the winter of 1983-84 an east-west transect across the Delta, following the route of the ice road, from Inuvik to Aklavik, was chosen. Gauges were installed only on major tributaries. This layout permitted monitoring ice growth throughout one region of the Delta and the collection of data which provided a rough indication of flow in channels during the winter months.

During 1982-83 it was thought that ice growth in some channels might extend to the bed across the channel and thus block flow. At the shallowest channel gauged (Bombardier Channel) ice growth continued until the last reading (April 12) but thickening slowed after February 10.

In 1983-84 ice growth at this same location reached a maximum on April 27, and ice thickness was between 103 and 108 cm for the period March 23 to April 17. After reaching 113 cm on April 27 the thickness declined to 106 cm by May 16. Thus, in neither winter did the ice attain the thickness required to stop discharge.

For the other common sites (Middle Channel) the average monthly values recorded for the period January to April show a close corelation both in timing and thickness (Figures 3 and 4). Average monthly values for January and February indicate reduced thickness in 1983-84. Mean daily air temperatures for January 1984 were considerably above those of the previous year which may explain such results (Figure 5).

Mean monthly total ice thickness values for sites in the eastern sector of the Delta attained similar values (approximately 100 cm) in both 1982-83 and 1983-84. The greatest variation occurs at the West Channel gauge location in the Winter of 1983-84. West Channel values were approximately 20 cm greater than those recorded elsewhere in the Delta.

A complete meterological record for 1983 and 1984, at Aklavik, does not exist. The limited, available data (Atmospheric Environment Service 1983, 1984) suggests that air temperatures are generally lower

at Aklavik. Recorded snow depths and snow character at the West Channel gauging sites suggest higher winds predominate along the western portion of the Delta. The resultant reduction in the insulating effect of snow cover is one factor, which, combined with that of lower temperatures may explain the values obtained for this one site.

Values for the Aklavik Channel site more closely approach values obtained at mid-Delta locations. To assist in resolution of the West Channel thickness anatomy, it is proposed to install additional gauges in 1984-85. Two gauges will be installed on Peel Channel, approximately 10 km upstream of Aklavik.

SUMMARY AND CONCLUSIONS

Winter ice thickness on the Mackenzie Delta reached maximum values in late April/early May, immediately prior to the start of Spring break-up processes.

In the winters of 1982-83 and 1983-84 the mean monthly thickness values were similar for common gauge sites. As the winter progressed mean maxima showed a trend of increasing thickness from east to west across the Delta. In 1983-84 West Channel values were considerably greater than expected on the basis of a linear increase with distance from the east side of the Delta. The reasons for these high values are not fully determined but it is likely that colder air temperatures, higher average winds and reduced snow cover on the ice combined to cause this phenomenon.

FUTURE STUDIES

In the winter of 1984-85 it is proposed to maintain a gauge network similar to that of 1983-84, with the exception that two additional gauges will be installed along the western margin of the Delta. These gauges should provide a verification of values obtained for West Channel gauges.

Results from the 1984-85 monitoring program should be available in late Summer 1985.

ACKNOWLEDGEMENTS

To Terry Prowse and Earl Burgess of the National Hydrology Research Institute, Ottawa, for input on the design changes to the gauges and production of the components for the gauges.

To Manuel Bosch of the Inuvik Scientific Resource Centre for field assistance and data handling.

REFERENCES

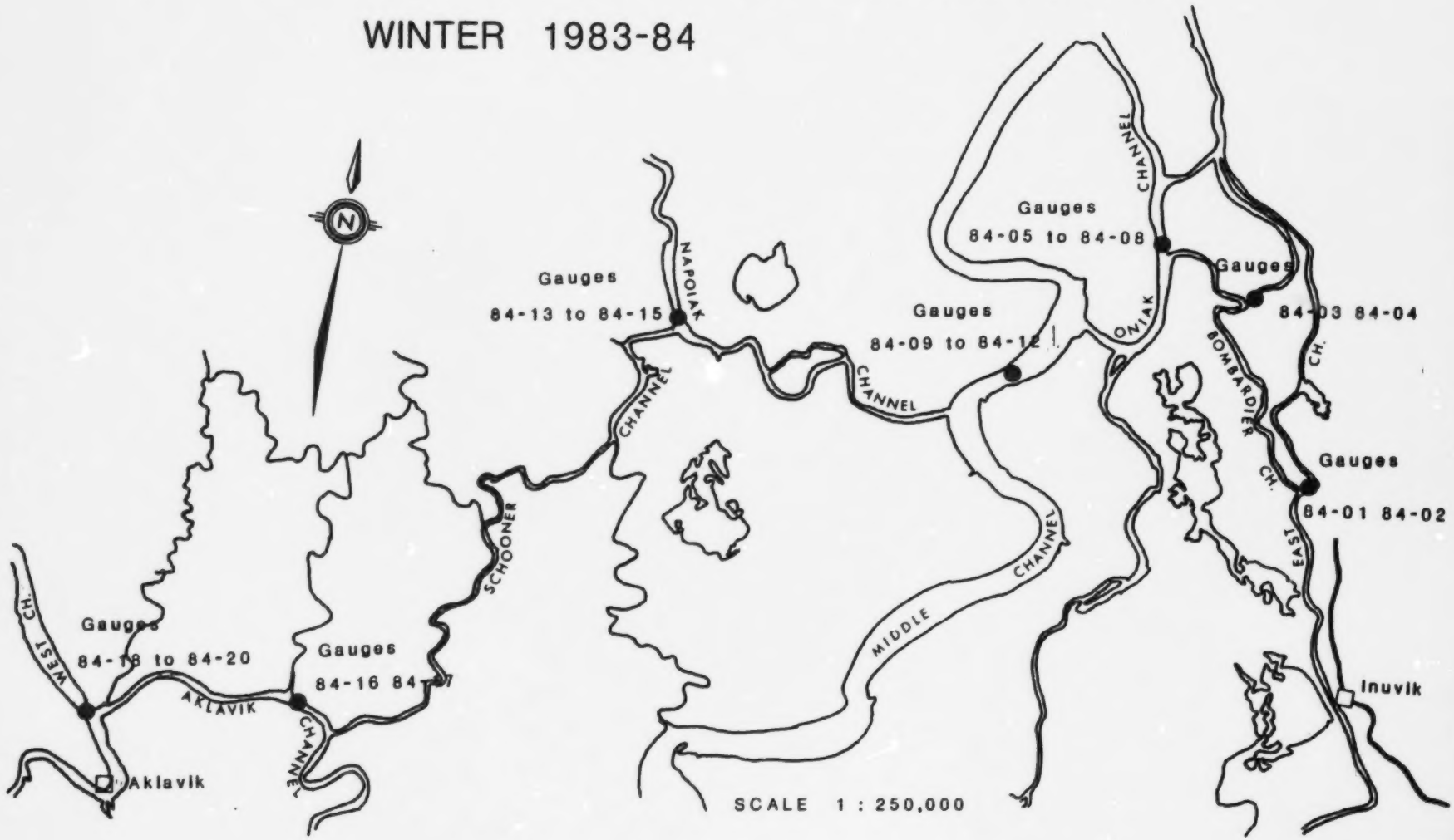
———(1983, 1984) "Monthly Record - Meterological Observations in Canada" Atmospheric Environment Service, Environment Canada, Ottawa, various publication dates and paginations.

Sherstone, D. A. (1984) "Ice Thickness in the Mackenzie Delta: Winter 1982-83: Data Obtained from Hot-Wire Gauge System" Report 84-1, Inuvik Scientific Resource Centre, Inuvik, N.W.T., February 1984, 16 p.

FIGURE 1

LOCATION OF ICE GAUGES, MACKENZIE DELTA, N.W.T.

WINTER 1983-84



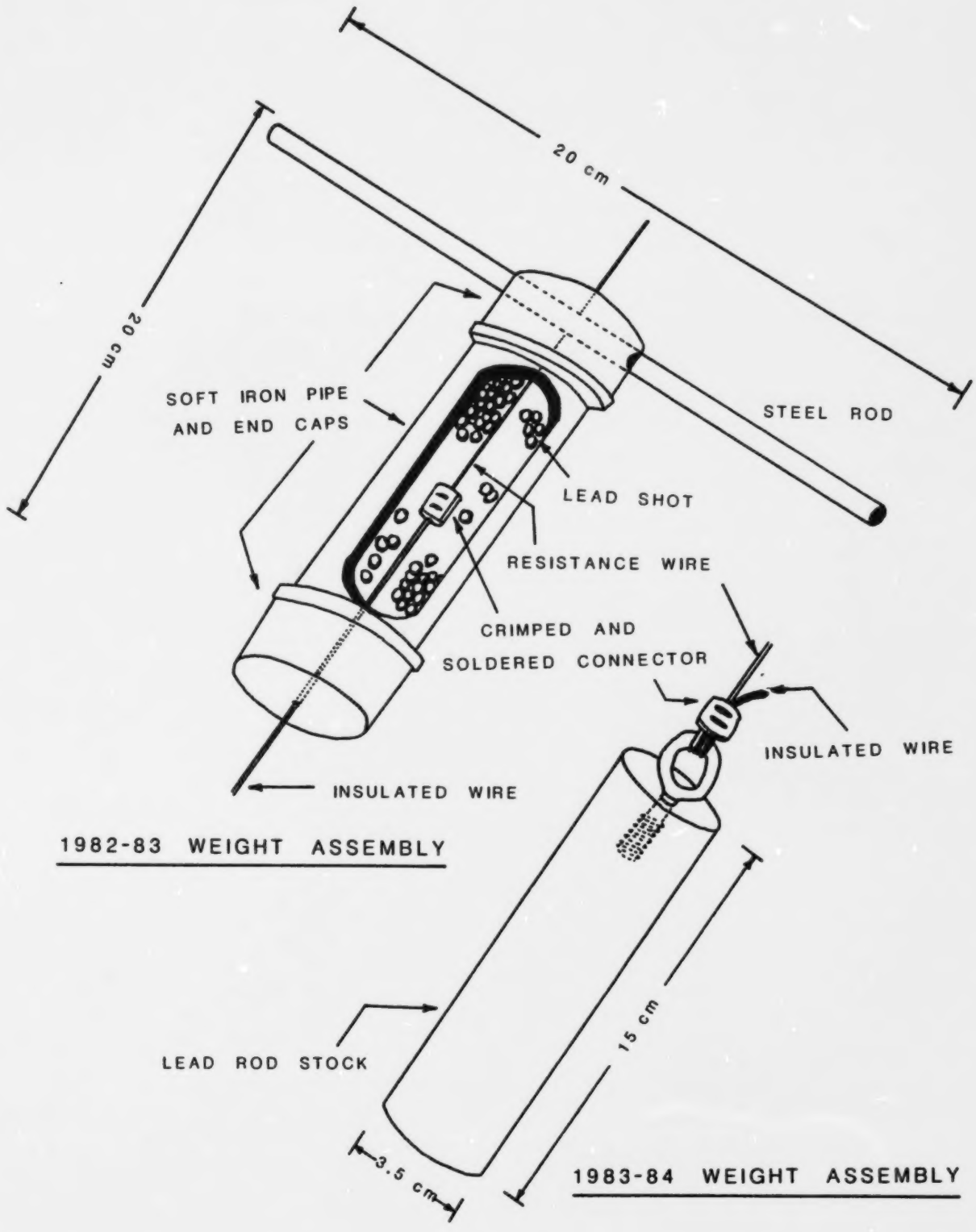


FIGURE 2

MODIFICATION TO WEIGHT ASSEMBLY AND WIRE FIXING

FIGURE 3

MEAN MONTHLY ICE THICKNESS FOR EACH RIVER CHANNEL MONITORED - WINTER 1983-84

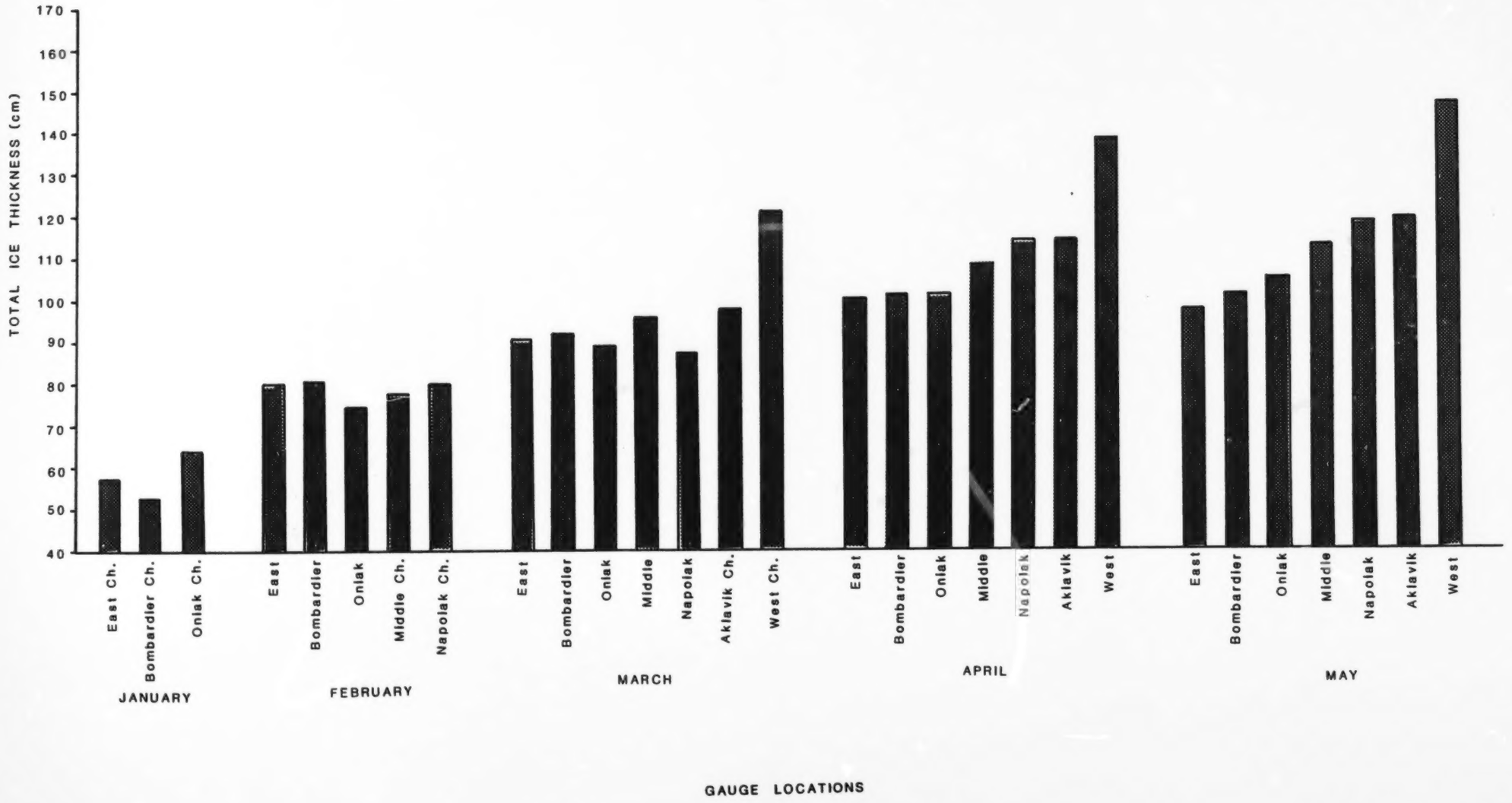


FIGURE 4

MEAN MONTHLY ICE THICKNESS FOR EACH RIVER CHANNEL MONITORED - WINTER 1982-83

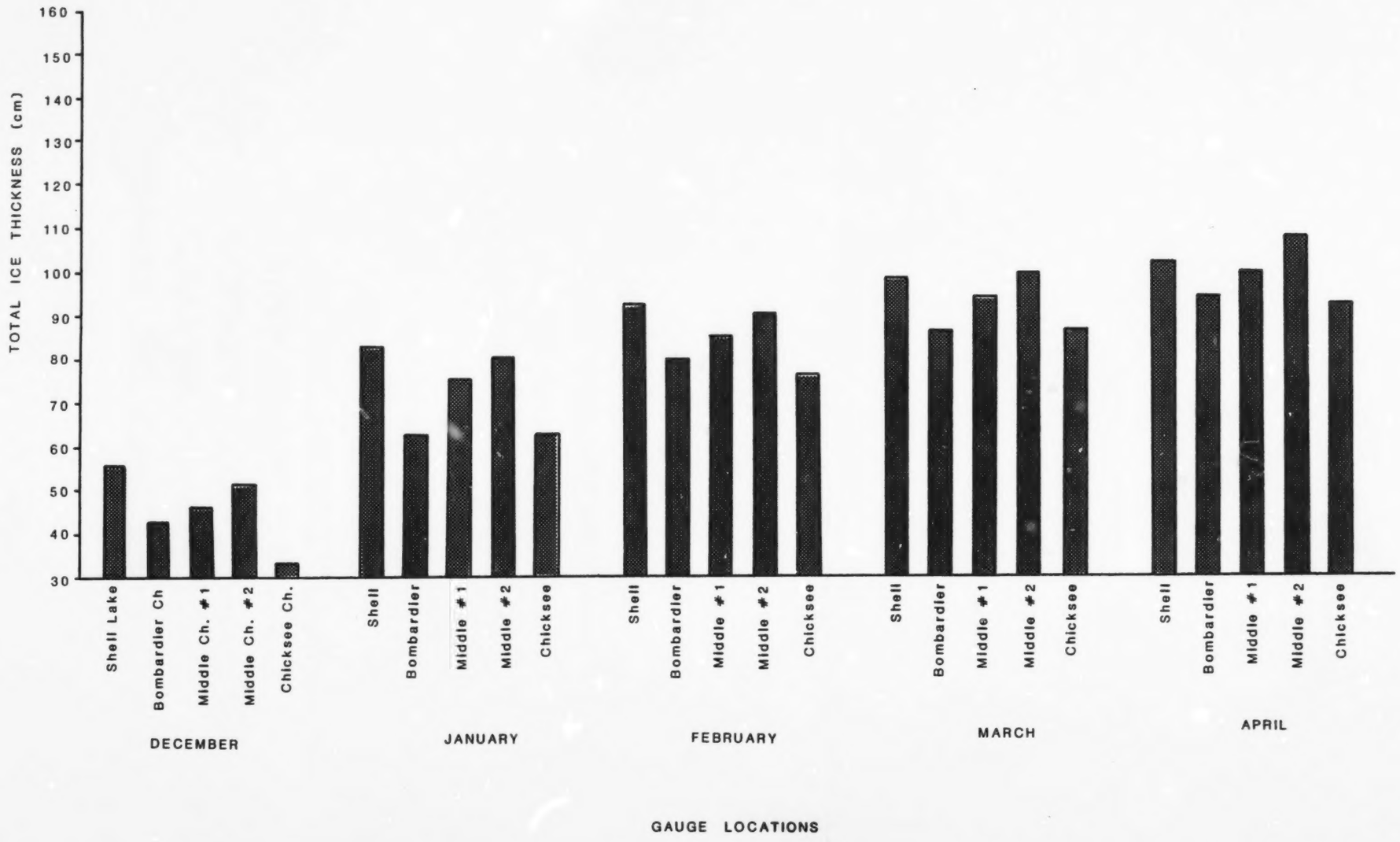
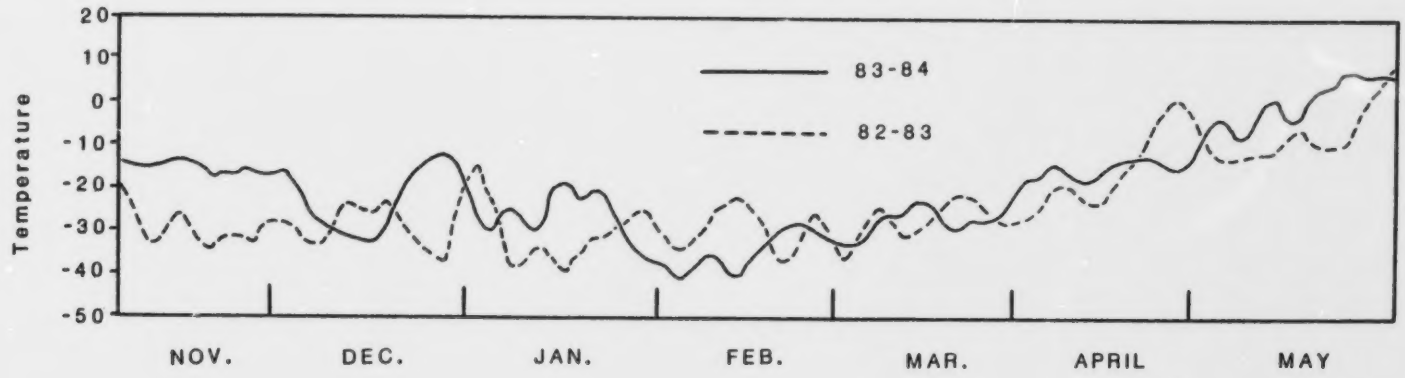


FIGURE 5

FIVE DAY, RUNNING MEAN:

MEAN DAILY AIR TEMPERATURES (DEG. C):

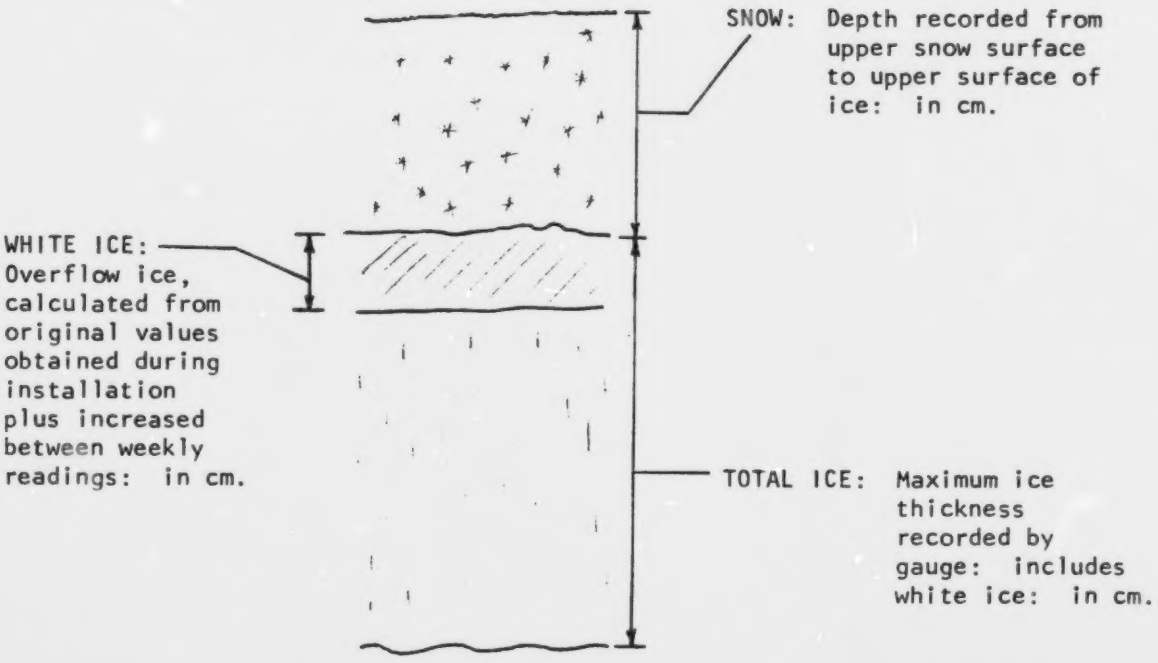
INUVIK AIRPORT: WINTERS 1982-83 1983-84



APPENDIX A:

RECORDED DATA FROM ICE GAUGES:

WINTER 1983-84


SNOW: Depth recorded from upper snow surface to upper surface of ice: in cm.
WHITE ICE: Overflow ice, calculated from original values obtained during installation plus increased between weekly readings: in cm.
TOTAL ICE: Maximum ice thickness recorded by gauge: includes white ice: in cm.

GAUGE 84-01

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 23	55.0	13.0	20.0
Feb 13	78.0	13.0	18.0
Mar 1	85.5	14.0	24.0
Mar 13	87.5	14.0	25.0
Mar 23	93.0	14.0	30.0
Apr 3	93.5	14.0	32.0
Apr 10	92.5	16.5	35.0
Apr 17	96.0	16.5	35.0
Apr 27	98.5	18.5	40.0
May 3	99.0	18.5	33.0
May 16	82.5	18.5	6.0

GAUGE 84-02

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 23	60.0	19.0	24.0
Feb 13	80.5	19.0	19.0
Mar 1	87.0	19.0	23.0
Mar 13	92.0	19.0	22.0
Mar 23	103.0	24.0	20.0
Apr 3	105.5	24.0	29.0
Apr 10	108.0	25.5	31.0
Apr 17	102.5	25.5	33.0
Apr 27	105.0	26.5	42.0
May 3	105.0	26.5	25.0
May 16	102.0	30.5	0.0

GAUGE 84-03

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 23	57.0	7.0	20.0
Feb 13	87.5	7.0	20.0
Mar 1	98.5	7.0	25.0
Mar 13	97.0	7.0	24.0
Mar 23	103.0	7.0	30.0
Apr 3	104.0	8.0	35.0
Apr 10	107.0	8.0	34.0
Apr 17	108.5	8.0	35.0
Apr 27	113.0	8.5	40.0
May 3	111.0	11.0	28.0
May 16	106.0	12.0	10.0

GAUGE 84-04

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 23	49.0	7.0	26.0
Feb 13	75.0	10.0	23.0
Mar 1	81.0	13.0	22.0
Mar 13	83.0	13.0	27.0
Mar 23	87.5	13.0	32.0
Apr 3	91.5	13.0	35.0
Apr 10	94.0	13.0	36.0
Apr 17	94.5	14.0	34.0
Apr 27	93.5	16.0	41.0
May 3	96.5	18.5	31.0
May 16	89.0	18.0	12.0

GAUGE 84-05

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 30	66.0	0.0	15.0
Feb 13	81.5	0.0	17.0
Mar 1	90.5	0.0	19.0
Mar 13	97.0	0.0	18.0
Mar 23	104.0	1.0	23.0
Apr 3	107.0	1.0	28.0
Apr 10	109.0	1.5	24.0
Apr 17	110.0	1.5	28.0
Apr 27	113.0	1.5	24.0
May 3	114.0	2.5	24.0
May 16	109.5	2.0	8.0

GAUGE 84-06

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 30	62.0	0.0	27.0
Feb 13	68.0	0.0	29.0
Mar 1	80.5	0.0	31.0
Mar 13	85.0	0.0	29.0
Mar 23	91.0	0.0	30.0
Apr 3	96.5	0.0	31.0
Apr 10	95.0	0.0	34.0
Apr 17	96.0	0.0	36.0
Apr 27	98.0	0.0	39.0
May 3	100.0	1.5	30.0
May 16	99.5	4.0	16.0

GAUGE 84-07

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 30	62.0	0.0	20.0
Feb 13	75.0	1.0	23.0
Mar 1	82.0	1.0	25.0
Mar 13	90.5	4.0	22.0
Mar 23	93.5	4.0	27.0
Apr 3	97.5	4.0	33.0
Apr 10	99.5	5.0	31.0
Apr 17	99.0	5.0	36.0
Apr 27	101.5	5.0	35.0
May 3	103.0	6.5	29.0
May 16	102.0	7.5	15.0

GAUGE 84-08

DATE	TOTAL ICE	WHITE ICE	SNOW
Jan 30	65.0	0.0	27.0
Feb 13	73.5	0.0	26.0
Mar 1	81.0	0.5	33.0
Mar 13	81.0	0.5	30.0
Mar 23	90.5	0.5	32.0
Apr 3	94.5	0.5	35.0
Apr 10	95.5	0.5	33.0
Apr 17	96.0	0.5	37.0
Apr 27	97.5	0.5	45.0
May 3	110.5	12.5	29.0
May 16	102.0	15.0	24.0

GAUGE 84-09

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	64.0	0.0	23.0
Feb 15	64.5	0.0	28.0
Mar 1	79.5	1.0	30.0
Mar 13	82.5	2.5	26.0
Mar 23	87.0	2.5	28.0
Apr 3	88.5	2.5	37.0
Apr 10	91.5	3.5	38.0
Apr 17	92.5	3.5	34.0
Apr 27	96.0	5.0	31.0
May 3	94.0	5.0	30.0
May 16	95.5	9.5	12.0

GAUGE 84-10

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	76.0	0.0	9.0
Feb 15	83.0	0.0	12.0
Mar 1	95.0	0.0	11.0
Mar 13	103.0	0.0	11.0
Mar 23	110.5	0.0	13.0
Apr 3	115.5	0.5	16.0
Apr 10	117.0	0.5	12.0
Apr 17	119.5	1.0	12.0
Apr 27	122.5	1.0	11.0
May 3	125.5	3.0	9.0
May 16	125.5	6.0	0.0

GAUGE 84-11

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	94.0	?	11.0
Feb 15	100.0	?	15.0
Mar 1	106.0	+2.0	24.0
Mar 13	112.5	+2.0	22.0
Mar 23	119.0	+3.0	26.0
Apr 3	123.0	+3.0	30.0
Apr 10	125.0	+3.0	31.0
Apr 17	126.5	+3.0	30.0
Apr 27	127.5	+3.0	40.0
May 3	129.5	+3.0	29.0
May 16	130.0	+6.5	20.0

GAUGE 84-12

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	67.0	6.0	24.0
Feb 15	72.0	6.0	24.0
Mar 1	77.0	6.0	32.0
Mar 13	83.5	7.0	28.0
Mar 23	89.0	8.0	28.0
Apr 3	93.0	8.0	37.0
Apr 10	95.0	8.0	34.0
Apr 17	95.0	8.0	36.0
Apr 27	99.5	10.5	32.0
May 3	100.0	11.0	28.0
May 16	98.5	11.0	17.0

GAUGE 84-13

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	80.0	9.0	24.0
Feb 15	86.0	9.0	23.0
Mar 1	94.0	10.0	24.0
Mar 13	97.0	10.0	29.0
Mar 23	104.0	11.5	31.0
Apr 3	109.0	11.5	30.0
Apr 10	110.5	11.5	34.0
Apr 17	113.0	13.0	30.0
Apr 27	114.0	13.0	31.0
May 3	115.0	13.5	30.0
May 16	115.0	17.5	17.0

GAUGE 84-14

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	60.0	0.0	15.0
Feb 15	60.5	0.0	33.0
Mar 1	70.0	0.0	30.0
Mar 13	77.0	1.0	26.0
Mar 23	82.5	1.0	34.0
Apr 3	86.0	1.0	34.0
Apr 10	88.0	1.0	30.0
Apr 17	87.5	1.0	31.0
Apr 27	89.5	1.0	30.0
May 3	91.0	1.5	21.0
May 16	92.5	10.0	9.0

GAUGE 84-15

DATE	TOTAL ICE	WHITE ICE	SNOW
Feb 6	110.0	9.0	16.0
Feb 15	-	-	20.0
GAUGE INOPERATIVE			
Apr 3	138.5	9.0	25.0
Apr 10	139.5	9.0	25.0
Apr 17	142.0	9.0	26.0
Apr 27	144.0	9.0	32.0
May 3	148.5	12.5	25.0
May 16	148.0	14.0	10.0

GAUGE 84-16

DATE	TOTAL ICE	WHITE ICE	SNOW
Mar 1	90.0	?	18.0
Mar 13	92.0	?	22.0
Mar 23	99.0	?	24.0
Apr 3	107.5	2.5	24.0
Apr 10	110.0	2.5	20.0
Apr 17	111.0	2.5	20.0
Apr 27	114.0	3.0	37.0
May 3	115.5	3.5	22.0
May 16	119.0	7.0	6.0

GAUGE 84-17

DATE	TOTAL ICE	WHITE ICE	SNOW
Mar 1	98.0	9.0	16.0
Mar 13	100.0	10.0	21.0
Mar 23	107.5	10.5	28.0
Apr 3	112.0	10.5	28.0
Apr 10	113.5	10.5	24.0
Apr 17	117.0	11.5	24.0
Apr 27	119.5	12.0	40.0
May 3	120.5	12.0	28.0
May 16	119.5	15.5	13.0

GAUGE 84-18

DATE	TOTAL ICE	WHITE ICE	SNOW
Mar 1	112.0	10.0	9.0
Mar 13	119.0	10.0	10.0
Mar 23	127.5	10.5	13.0
Apr 3	133.5	10.5	17.0
Apr 10	136.5	10.5	14.0
Apr 17	138.5	10.5	13.0
Apr 27	141.5	10.5	15.0
May 3	144.0	11.0	13.0
May 16	146.0	20.0	0.0

GAUGE 84-19

DATE	TOTAL ICE	WHITE ICE	SNOW
Mar 1	122.0	12.0	10.5
Mar 13	124.0	12.0	14.0
Mar 23	132.5	12.5	12.0
Apr 3	138.0	12.5	17.0
Apr 10	141.0	12.5	15.0
Apr 17	143.5	12.5	18.0
Apr 27	145.5	12.5	18.0
May 3	149.0	15.0	10.0
May 16	146.0	19.0	0.0

GAUGE 84-20

DATE	TOTAL ICE	WHITE ICE	SNOW
Mar 1	115.0	0.0	18.0
Mar 13	118.0	0.0	18.0
Mar 23	124.5	0.0	20.0
Apr 3	130.5	0.0	23.0
Apr 10	132.5	0.0	19.0
Apr 17	135.0	0.0	20.0
Apr 27	137.5	0.0	20.0
May 3	150.0	2.5	15.0
May 16	142.0	5.5	0.0